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A DEVICE FOR LAUNCHING AN AIRCRAFT

The invention relates to a device for launching an aircraft. Such a device can commonly be referred to as an "aircraft catapult" and makes it possible, over a short distance, to impart sufficient speed to an aircraft for it to take off. Such catapults can be encountered, in particular, on naval ships such as aircraft carriers or cruisers.

Most known catapults are of the type comprising a guide ramp that defines a launch trajectory, an aircraft-support carriage mounted to move along said ramp, and a drive system and/or a brake system for driving and/or braking the carriage. In the past, various kinetic energy sources have been used for such drive-and-brake systems.

After the Second World War, most aircraft carrier catapults had hydro-pneumatic drive systems. Compressed-air catapults were also proposed, as were steam catapults (which were subsequently used widely because of the availability of steam on naval ships).

Such catapults suffer from the drawbacks of being often voluminous and of involving large moving masses. Therefore voluminous and complex braking systems are necessary. Of such launch devices, steam catapults are the least voluminous. But their open-actuator design gives rise to low efficiency.

Generally, none of those catapults that use pressurized fluid, nor any of those catapults whose drive system uses elastic links or bungee cords, e.g. used for automobile crash tests, make it possible to reach high launch speeds. And yet modern aircraft can frequently take off only once they have reached very high speeds, of about 100 meters per second. Neither bungee catapults nor pressurized-fluid catapults that are currently available make it possible to impart to an aircraft a speed greater than 55 meters per second over a distance

as short as the length of an aircraft carrier flight deck.

Document EP-A-320 035 describes a catapult system driven by a hydraulic motor and equipped with a carriage pulled by a cable. In that system, the cable is wound on a winch that is placed on the ramp in a manner such that, on going past the winch, the direction of traction exerted by the cable on the carriage changes, while the direction of operation of the hydraulic motor of the winch remains the same. Under the effect of the traction of the cable, that change of traction direction causes braking that is suitable for launching the aircraft placed on the carriage. Unfortunately, that known catapult does not make it possible to obtain the desired launch speeds.

In order to overcome that problem, solid-propellant propulsion units can be mounted on the aircraft to be launched. Solid-propellant propulsion units also suffer from drawbacks. Since they contain explosives, their possibilities of use are limited. In addition, that technique is costly because, on each launch, the propulsion units used must be jettisoned and therefore lost.

An object of the invention is thus to provide a launch device that uses a re-usable drive system - i.e. without any consumable element such as solid-propellant propulsion units, while also making it possible to attain launch speeds greater than 100 meters per second and while limiting the overall size of the catapult and the moving masses, so as to make it possible to reduce the braking distance to a short as possible. Another object of the invention is to enable the device to be adapted efficiently to various sources of energy, in particular hydraulic and/or pneumatic, depending on what is available on the site on which it is used.

To these ends, the invention provides a device for launching an aircraft, which device is of the type

comprising a guide ramp, a carriage for supporting the aircraft, and a drive-and-brake system for driving the carriage along the ramp and for braking it, said device being characterized in that said system comprises a transmission member such as a pulley, mounted to move on the ramp and secured to a kinetic energy source, e.g. an actuator, and a cable or the like anchored to the ramp and suitable for co-operating with the carriage, the transmission member co-operating with the cable to form a geared transmission mechanism for geared transmission of kinetic energy, between the carriage and the source.

This gearing of the kinetic energy transmission ratio - i.e. of the associated movements of the carriage and of the outlet of the source - makes it possible, with said source having limited power, to obtain large variations in movement of the carriage. Since said kinetic energy can also be transmitted to or absorbed by the source, the term "source" covers not only a drive element such as an actuator, but also a braking element such as a damper.

Other features and advantages of the invention appear more clearly from the following detailed description given with reference to the accompanying drawings which are given merely by way of example, and in which:

- Figure 1 is a diagrammatic side elevation view of an embodiment of the invention;
- Figure 2 is a plan view of the embodiment of Figure 1;
- Figure 3 is a section view on line III-III of the embodiment of Figures 1 and 2;
- Figure 4 is a fragmentary view seen looking along arrow IV of a detail of the brake mechanism of the embodiment of Figures 1 to 3; and
- Figure 5 is a diagrammatic view of the pressurized fluid feed for a drive-and-brake system dedicated to a device of the invention.

In the drawings, X-X' designates a longitudinal axis corresponding to the trajectory along which a craft such as an aircraft 1 that can be seen in Figure 1, is to be launched. The launch is made by means of an aircraft catapult or launch device 20. In known manner, the catapult 20 comprises a guide ramp 21 that extends parallel to the trajectory X-X'.

As shown in Figures 1 to 3, the ramp 21 is made up of all-welded elements, arranged around a central and longitudinal beam 210. Crosspieces 212, and stiffeners 214 disposed in V-shaped configurations are fastened rigidly at regular intervals along X-X' to the central beam 210, so as to form a rigid support structure. The ramp 21 defines, at its top in this example, a main guide rail 216 parallel to X-X'. The main rail 216 is provided with two channel-section longitudinal side recesses spaced apart from each other and having their concave faces facing each other. Each longitudinal recess in the main rail 216 can receive and guide along X-X' two wheels or blocks 122 of a carriage 12 for supporting the aircraft 1. A high-density polyamide can coat the tread strips of the wheels 122 of the carriage 12.

In the example shown, the ramp 21 has a length along the axis X-X' of about 68.5 meters, this dimension making it possible to define, also along the axis X-X', an acceleration zone A in which the carriage 12 supporting the aircraft 1 accelerates. The zone A has a length of about 56 meters and extends from a starting position (Figure 1) of the carriage-and-aircraft assembly, to the inlet of a deceleration or braking zone F that has a length of about 7 meters. The ramp 21 can be equipped with legs or posts 218, preferably of variable height, in order to impart to the trajectory X-X' a slope of about 2° (upwards and leftwards in Figure 1). The ramp 21 can also be provided with anchorages for fastening to any support, such as a construction or a naval ship.

A ramp having a length of about 20 meters, but of comparable structure, can be mounted on a motor vehicle.

In the vicinity of the rail 216 and at the end thereof that is opposite from the zone F, a winch 321 is provided for bringing the carriage 12 back to the starting position, in particular after the aircraft 1 has been launched. The winch 321 is provided with a hook 31 by means of which the carriage 12 is held in the starting position, until said hook 31 opens.

The device 20 further comprises a system for driving and for braking the carriage 12 along the ramp 21. This drive-and-brake system, designated by overall numerical reference 4, includes a first mechanism that acts when the carriage 12 lies within the zone A, and that is assigned to moving said carriage. A second mechanism acts when the carriage 12 is present in the zone F, and serves to brake said carriage. Both of the mechanisms use geared transmission of kinetic energy between the carriage 12 and the source of movement or of damping. In general, the transmission members, and indeed almost the entire system 4, are arranged inside a space defined by the ramp 21. This configuration that is suitable for maximizing the compactness of the catapult 20, is, in particular, made possible by the fact that the majority of the movements of parts in the system 4 take place approximately parallel to X-X', and thus linearly. The active movement direction or work direction is reversed between the carriage and the corresponding source of kinetic energy. During the launch, the carriage 12 is moved from right to left with reference to Figures 1 and 2. Whereas, the respective kinetic energy sources of the drive and brake mechanisms work from left to right, as indicated by the arrows T, parallel to X-X'. This result that also makes it possible to improve compactness, by "superposing" the work movements, is obtained by make provision for one of the link cables between the carriage 12 and either the drive mechanism, or the brake

mechanism, to co-operate with a stationary pulley. In this example, a cable 410 that connects the carriage 12 to a drive mechanism 42 co-operates with a pulley 412, by being wound over one half of the circumference thereof. The pulley 412 is fastened to the ramp 21, to the end thereof that is opposite from the winch 321. Similarly, a brake mechanism 43 is to be found at the zone F. The brake mechanism comprises a cable 411 that is designed to co-operate with the carriage 12 and that is wound around two pulleys 413 that are fastened to the ramp 21.

Figure 1 shows that, in the system 4, and more precisely in the drive mechanism 42, at least two transmission members are connected in series to at least one common source of kinetic energy. In this example, the transmission members are pulleys. The pulleys arranged in series of the drive mechanism 42 are designated (from right to left in Figures 1 and 2) 422, 424, and 426. The kinetic energy source of the acceleration mechanism is hydro-pneumatic in this example. It could be hydraulic or pneumatic.

Figure 5 shows a hydro-pneumatic actuator 420 that is the energy source for the drive mechanism and that is disposed in a central position and parallel to X-X', in the ramp 21. The actuator 420 has an outlet rod 432 that is secured to or integral with its piston, and it is moved in the direction indicated by arrow T while the aircraft 1 is accelerating (zone A).

It can be seen in Figures 1 and 2 that the actuator 420 is equipped, at its end opposite from its rod 432, with an end-of-course damper 428.

Batteries of accumulators 434 are designed to deliver the energy necessary for the actuator 420, by expansion of a pressurized gas. For each accumulator of the series 434, a valve 436 is provided that makes it possible to establish fluid communication or to interrupt the flow of fluid between the accumulators and the actuator. The zone defined by dot-dash lines and

referenced 44 represents a feed or a generator that makes it possible to reactivate the energy for the system after an aircraft launch. Reference 442 designates a valve for emptying the actuator, while reference 446 indicates a valve making it possible, if necessary, to discharge the accumulators 434.

In the example shown in Figure 2, and for reasons of balancing and of limiting the stresses, the transmission pulleys 424 are doubled, while the pulleys 422 are quadrupled. In order to simplify the description, regardless of the number of parallel pulleys of a transmission member, said transmission member is a considered to be single member, as can be understood by observing Figure 1 alone.

The outlet of the actuator 420 is connected to the pulley 422 via a carriage 442, which is referred to as a "shuttle" to avoid any confusion with the aircraft support carriage 12. Similarly to the support carriage, the shuttle 442 is guided along X-X' inside the ramp 21 by a middle double rail 241 (Figure 3) that is also fastened rigidly to the inside of the beam 210. It is the shuttle 442 that supports the axles of the pulleys 442.

Each pulley 422 windingly receives an intermediate cable 438 whose end closer to the actuator 420 is anchored at 444 to the ramp 21, while its other end is fastened to an intermediate shuttle 452. The intermediate shuttle 452 is comparable to the shuttle 442, except that it supports the axles of the pulleys 424 and that it is guided inside the beam 210, by a bottom double rail 242 (Figure 3). An outlet cable 448 is wound over the pulley 424, which outlet cable has a stationary point 454 that is stationary relative to the beam 21 and a connection to a third shuttle 456. The third shuttle 456 supports the transmission pulley 426 over which the drive cable 410 is wound. At its end opposite from its connection to the support carriage 12, the cable 410 is

fastened to the ramp 21 via an anchorage 458. The shuttle 456 for supporting the pulley 426 is mounted to move along X-X', inside the rail 241.

The succession of shuttles 442, 452, and 456 equipped with the respective pulleys 422, 424, and 426 on which the cables 438, 448, and 410 are wound form gearing for gearing up the movement T of the actuator 420. Schematically, since any movement of a shuttle over a length "

over the corresponding pulley, not only the distance of displacement of a shuttle but also its velocity are doubled relative to those of the parts of the same mechanism that are situated closer to the kinetic energy source 420. In this example, the gearing comprises three stages in series, resulting in a ratio of eight for one for the velocity and displacement of the source 420 and of the carriage 12.

The brake mechanism 43 (Figures 2 and 4) comprises at least two transmission members connected in parallel to one or more kinetic energy sources. In order to be able to absorb the energy associated with the high velocity at which the assembly comprising the carriage 12 and the aircraft 1 is moving, and in order to cause said aircraft to be launched, the brake system 43 comprises two sources designated at 460 and comprising hydraulic and/or pneumatic dampers. These dampers 460 disposed on either side and are mounted inside the space defined by the ramp 21, parallel to X-X'. The rods 463, which are designed to work in power in the direction T, support at their free ends, i.e. at their ends opposite from the bodies of the dampers, axles for receiving transmission members 461. In this example, the members 461 are pulleys around which the brake cable 411 is wound. Like the pulleys 413, the pulleys 461 extend in a plane parallel to X-X'. Said plane is perpendicular to a plane containing the trajectory X-X', and about which the device 20 is substantially symmetrical.

The cable 411 that is tensioned between the two stationary pulleys 413 perpendicularly to X-X' and that is wound around the two moving transmission pulleys 461, is fastened to each of its ends 465, to the ramp 21.

In addition, the carriage 12 forms a shoe at its front end, i.e. at its end opposite from the winch 321 along X-X'. It is at this shoe that the drive cable 410 is anchored to the carriage 12. Unlike what is observed for the mechanism 42, the mechanical link between the carriage and the brake mechanism is not permanent, because it occurs only at the time when the carriage penetrates into the zone F. It is at the junction between the zones A and F that the cable 411 is tensioned perpendicularly to X-X', and across the path along which the carriage 12 passes. As shown in the upper portion relative to X-X' of Figure 4, when the carriage 12 penetrates into the zone F, its shoe comes into contact with the tensioned cable 411. The dampers 460 are then in their relaxed positions, in which the distance between the pulleys 413 and 461 is maximized. As the carriage 12 penetrates into the zone F (in the direction opposite to T), the shoe of said carriage tenses the cable 411 in the manner of a bow. The run of the cable 411 that serves as an abutment for stopping the carriage is situated between the pulleys 413, thereby doubling the working length of cable during the braking. In order to compensate for this increase in length, but in geared-down manner, the damper rods 463 penetrate into their respective bodies, i.e. in the direction T. This movement enables kinetic energy to be absorbed and causes the carriage to be braked proportionally. At the end of the zone F, all of the kinetic energy of the carriage that is accumulated as it passes through the zone A is absorbed by the dampers 460, so that the carriage is stopped in the position shown in the lower portion of Figure 4.

The device operates as follows. The carriage 12 is locked in the starting position by the hook 31, and the

aircraft 1 is fastened to the carriage 12. A pressurized fluid (gas) is stored in the accumulators 434, the valves 436 being closed. The end-of-stroke dampers are positioned.

The device is put under tension by opening the valves 436 that feed the actuator 420. The engine or propulsion unit of the aircraft is switched on, if necessary. The hook 31 is then opened, so that, under the effect of the force from the actuator 420, the various cables of the drive or acceleration mechanism put the carriage-and-aircraft assembly into motion. It should be noted that the working stroke of the actuator 420 is equal to A/8. The acceleration applied to the carriage 12 is slightly decreasing acceleration due to the limited capacity of the accumulators 434. At the end of the zone A, the carriage-and-aircraft assembly has reached a velocity sufficient for it to take off. For example a velocity V = 105 meters per second can be obtained with a mean acceleration $a_m = 100\ m/s^2$.

The carriage-and-aircraft assembly, moving at maximum velocity, penetrates into the zone F and is subjected to high deceleration by the dampers 460 compressing in direction T. It should be noted that the action of the brake mechanism 43 also causes the shuttles of the mechanism 42 to decelerate. Conversely, the actuator 420 is braked by its own damper 428. The braking distance F is designed so that the tension of the cables 411, 448, 438 is analogous to the tension observed in those cables during the acceleration stage. The mass to be braked is equal to the mass to be accelerated minus the mass of the aircraft 1 which, under the effect of its inertia, is released from the carriage 12 as of the start of the braking stage and continues its course in flight, by means of the velocity attained on the catapult.

In order to perform the next launch, the feed valves 436 are closed, and then the emptying valve 442 is opened so as to reinitialize the actuator 420. Similarly, the

dampers 460 are put back into their original states. The carriage 12 is brought back by the winch 321, as are the shuttles. After the hook 31 has been locked onto the carriage 12, the feed 44 is started up again so as to feed the accumulators 434 again.

The ramp 21 can also constitute a superstructure disposed above the carriage 12, the aircraft then being suspended from said carriage.

CLAIMS

1. A device for launching an aircraft (1), which device is of the type comprising a guide ramp (21), a carriage (12) for supporting the aircraft, and a drive-and-brake system (4) for driving the carriage along the ramp and for braking it, said device being characterized in that said system comprises a transmission member (422, 424, 426, 461) such as a pulley, mounted to move on the ramp (21) and secured to a kinetic energy source (420, 460), e.g. an actuator, and a cable (410, 411) or the like anchored to the ramp and suitable for co-operating with the carriage (12), the transmission member co-operating with the cable to form a geared transmission mechanism (42, 43) for geared transmission of kinetic energy, between the carriage and the source.

2. A device according to claim 1, characterized in that the drive-and-brake system (4) comprises a mechanism (42) assigned to moving the carriage (12) and a mechanism (43) serving to brake said carriage.

3. A device according to claim 1 or 2, characterized in that at least two transmission members (422, 424, 426) are connected in series to at least one common kinetic energy source (420), inside a transmission mechanism (42).

4. A device according to any one of claims 1 to 3, characterized in that one or more transmission members are connected via a shuttle (442, 452, 456) to the corresponding kinetic energy source (420).

5. A device according to any one of claims 1 to 4, characterized in that the above-mentioned transmission cable (410, 411) co-operates with a stationary pulley (412, 413) interposed between the carriage and the corresponding kinetic energy source (420, 460), so that

said carriage and said corresponding kinetic energy source move in mutually opposite directions.

6. A device according to any one of claims 1 to 5, characterized in that the above-mentioned transmission members (422, 424, 426, 461) are arranged inside a space defined by the ramp (21).

7. A device according to any one of claims 1 to 6, characterized in that the above-mentioned drive-and-brake system (4) comprises at least two transmission members (461) connected in parallel to one or more kinetic energy sources (460).

8. A device according to any one of claims 2 to 7, characterized in that the above-mentioned carriage (12) is provided with a shoe or the like suitable for co-operating with the cable (411) of the brake mechanism (43) by abutting thereagainst, when it comes into register with a "braking" zone (F) of the ramp.

9. A device according to any one of claims 1 to 8, characterized in that the above-mentioned kinetic energy source is pneumatic and/or hydraulic.

10. A device according to any one of claims 1 to 9, characterized in that, in the above-mentioned system (4), a transmission mechanism assigned to moving the carriage (12) is coupled to a central actuator (420) provided with end-of-stroke damping (428) and fed with pressurized fluid via a battery of accumulators (434), while a mechanism (43) serving to perform the braking is coupled to two side dampers (460), the central actuator and the side dampers being mounted parallel to the trajectory (X-X' of the carriage, and inside a space defined by the ramp (21).

ABSTRACT

The drive-and-brake system (4) for driving the carriage along the ramp and for braking it comprises a transmission member (422, 424, 426, 461) such as a pulley, mounted to move on the ramp (21) and secured to a kinetic energy source (420, 460), e.g. an actuator, and a cable (410, 411) or the like anchored to the ramp and suitable for co-operating with the carriage (12), the transmission member co-operating with the cable to form a geared transmission mechanism (42, 43) for geared transmission of kinetic energy, between the carriage and the source.